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Problems in the Use of Soil-acting Herbicides*

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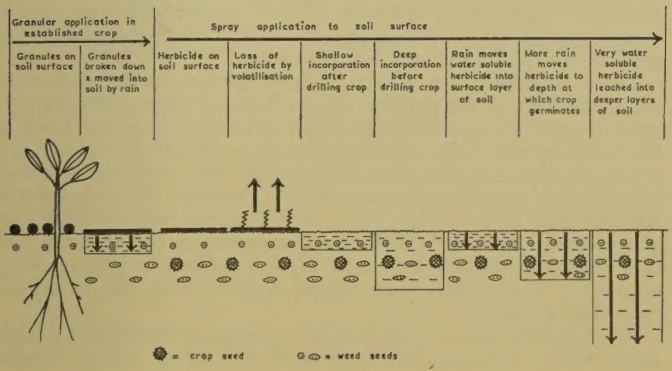
MANY OF the newer herbicides do not enter the foliage of weeds in effective amounts but are taken up from the soil by germinating seedlings. Others, which can penetrate into leaves, nevertheless may produce useful effects on germinating weeds via the soil. Many of the problems involved in the application of such herbicides to soil are quite different from those arising when a selective herbicide capable of foliar entry is sprayed over both crop and weed after emergence. The interpositioning of that complex and variable material—the soil—between the machine used for herbicide distribution and the weeds it is desired to kill is responsible for most of these problems.

The problems arising may be considered by following the course of events after application of the herbicide to the soil surface. This sequence is illustrated below. In this account the special case of soil fumigants, which may control weeds as well as dealing with other pests, is not considered.


Granular application in established crop
Spray application to soil surface
Granules on soil surface
Granules broken down & moved into soil by rain
Herbicide on soil surface
Loss of herbicide by volatilisation
Shallow incorporation after drilling crop
Deep incorporation before drilling crop
Rain moves water soluble herbicide into surface layer of soil
More rain moves herbicide to depth at which crop germinates
Very water soluble herbicide leached into deeper layers of soil
= crop seed
= weed seeds

The sequence of possible events following applications of a soil-acting herbicide.

* Based on paper given at Herbicide Refresher Symposium for N.A.A.S. Regional Crop Husbandry and Grassland Officers, 19 January, 1961.

Loss from Soil Surface

When a herbicide is sprayed on to a dry soil surface the chemical remains at or very near the surface. It may then be particularly liable to loss by:

1. photochemical decomposition, particularly in ultra-violet light. This is known to occur with monuron, probably with simazine, and possibly with other herbicides;
2. volatilization into the atmosphere. This is known to occur with chlorpropham, EPTC, 2,6-dichlorobenzonitrile, 2,3-dichloroallyl diisopropylthiolcarbamate ("Avadex"), and dinoseb. These are all chemicals which would not be regarded as highly volatile at room temperature but of which loss from this cause can be considerable. It must be remembered that soil surface temperatures may be considerably higher than air temperatures, and that volatilization may be appreciably greater from moist than from dry soil, due to a process akin to steam distillation.

Incorporation into Soil

Herbicides subject to volatility loss need to be incorporated into soil by mechanical means. Sometimes incorporation is desirable within an hour or so of spraying. The maximum time interval permissible between application and incorporation depends on the chemical and its formulation, the temperature, and the level of soil moisture. Volatilization may be less from granular formulations, in that a smaller surface area of soil is impregnated with herbicide than is the case where the herbicide is applied as a spray over the whole soil surface.

Soil incorporation may also be required to place the herbicide at or below the level of the germinating weed seeds, where generally it is most effective. A water soluble herbicide will usually be carried down to this depth by rain, but a relatively insoluble herbicide applied to a dry soil at the beginning of a dry spell may not reach that level unaided. The depth of incorporation required will vary with the crop and the weed problem to be tackled. Different implements and soil conditions give different degrees of efficiency of incorporation, but uniformity of distribution through the cultivated depth is difficult to achieve. With deep-sown crops a shallow incorporation of herbicide can be accomplished after drilling.

A recent development in the U.S.A. has been the formulation of soil-acting herbicides as granules. These are shed by foliage and can thus be applied to established crops. Mechanical incorporation in such situations is not always possible, and rain is then required to break down the granule and carry the herbicide into the soil to the zone where the weed roots are active. Attempts have been made to develop granules which release the herbicide at different rates but so far they all break down quickly when moist with rain or dew.

Adsorption

On entry into soil the herbicide is subjected to many physical, chemical, and biological processes. One is adsorption, which results in the herbicide being bound on the surfaces of organic matter and clay colloids. This adsorption renders the herbicide biologically unavailable. The degree of adsorption varies widely according to herbicide and soil type. The table below shows the range of doses required to produce the same effect on an annual grass when incorporated in a variety of soil types in the laboratory in the absence of leaching.

The pure silica sand has no adsorbing surfaces, whereas the "old muck" soil (American equivalent to our "black fen") contains over 80 per cent organic matter. The adsorption ratio in the last column is the ratio of the dose required in sand to that required in muck. This figure ranges from 1, indicating no variation with soil type and thus no adsorption problem, to 80 with PCP. The range between the two extremes of growing media is much greater than in normal agricultural soils in Britain, but the data show clearly how the performance of herbicides with the higher ratios can be markedly influenced by soil type.

Doses required to produce same effect on *Digitaria sanguinalis* in various soil types in absence of leaching

	Silica sand	Fine sandy soil	Silt loam soil	"Old muck" soil	Adsorption ratio
TCA	4	4	4	4	1
Dalapon	6	6	6	6	1
Dichloral urea	8	8	8	8	1
2,3,6-TBA	2	2–4	2–4	2–4	1–2
2,4-D	0·5	1	1	4	8
2,4,5-T	2	2–4	4	16	8
Monuron	0·25	0·75	1	6	24
Diuron	0·25	0·5	2	12	48
Chlorpropham	1	4	12	64	64
Dinoseb	4	6	24	128	32
PCP	8	16	64	640	80

(These data are reproduced by kind permission of Professor G. F. Warren, Purdue University, Indiana, and are unpublished, though the results are summarized in Proc. 13th North Central Weed Control Conference, 1956, 5.)

Leaching

Rainfall may cause leaching of the herbicide. The degree of leaching can vary greatly in extent, according to the chemical concerned. It depends primarily on the water solubility of the herbicide, but there is no precise relationship between solubility and ease of leaching. In the absence of

incorporation, leaching can be an advantage in carrying the herbicide to the germinating weed, which may be near the surface, as with chickweed and mayweed or at a wide range of depths, as with wild oat.

Excess leaching may take the herbicide down to the roots of a crop relying partly on depth protection for safety. In a few instances leaching may occur so readily that the herbicide disappears beyond reach of most roots and may be lost so far as biological effects are concerned. TCA, dalapon and chlorate are very readily leached. 2,3,6-TBA, amiben, and CDAA are readily leached in all but organic soils. 2,4-D, 2,4,5-T, dinoseb and dichloral urea are leached in sandy soils but not in loams or organic soils. PCP, simazine and monuron are not readily leached in any soil. Diuron, neburon, and chlorpropham are almost completely resistant to leaching.

Persistence in Soil

Leaching is only one of the factors responsible for the disappearance of herbicidal effects from soil. Others which may be important include (1) uptake and breakdown by resistant plants—simazine is metabolized by resistant plants such as maize; and (2) chemical breakdown in soil—hydrolysis of CDAA, CDEC, and dalapon may occur in soil, for instance. Far and away the most important factor, however, is microbiological breakdown. In one notable instance, that of 2,4-DES, breakdown to 2,4-D is essential for the action of the herbicide. More generally the active herbicide is converted to inactive breakdown products.

It is unlikely that any organic herbicide is completely resistant to micro-organisms, but there are very great differences in the time taken for breakdown. Compare the long period of persistence of ureas and triazines with the short period of 2,4-D. There is considerable variation between closely related compounds. Thus 2,4,5-T takes about three times as long as 2,4-D. TCA takes about seven times as long as monochloroacetic acid.

There is a strong correlation between conditions favourable for bacterial growth and the speed of disappearance of toxic residues of a herbicide. High moisture, temperature, and organic matter are all favourable. In particular, soil may become so dry or so cold as to stop breakdown completely. In many instances there is a lag phase during which there is little or no disappearance, followed by a period of rapid breakdown. This phenomenon is thought to be due to the time taken for the soil to develop a microflora capable of detoxicating the specific herbicide. Once a soil has built up the ability to break down a herbicide, subsequent doses of the same herbicide may be detoxicated without a further lag phase. Therefore the situation might arise whereby the same soil-acting herbicide applied to the same area at too frequent intervals may not give weed control for the expected period because of quicker breakdown.

Recapitulation

What has to be borne in mind when making recommendations for the use of a soil-acting herbicide?

1. Is the herbicide likely to damage the crop foliage if already present? If so, consider use of granular formulations or special directed-application equipment.
2. Is there likely to be loss of herbicide by volatilization? Or by ultra-violet decomposition? Or is soil surface dry, and prospect of rain poor, so that herbicide will not move into soil? If so, incorporate the herbicide into the soil. Depth of incorporation has to be considered in relation to (a) rooting habit of crop if it is perennial, (b) germination zone of weed seeds, and (c) whether crop is inherently resistant to herbicide and so will tolerate its presence at sowing depth.
3. Is the herbicide readily adsorbed on organic matter and colloids? If so, pay considerable attention to soil type when determining dose.
4. Is the herbicide prone to leaching? If so, soil-type and rainfall will be important, particularly if the crop depends partly on depth protection for resistance.
5. Has the herbicide to be converted to another compound to become active? If so, are soil moisture and temperature conditions appropriate?
6. Has the herbicide an appreciable period of persistence in the soil? If so, are conditions of soil type, likely moisture content and temperature, and cropping, conducive to the carry over of the herbicide to an ensuing susceptible crop?

Use of Nitrogenous Fertilizers on Grassland

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A RECENTLY published report covering 1957–58[1] indicates that for England, Scotland, and Wales, the overall application of nitrogenous fertilizers to leys averaged 19 lb nitrogen per acre, and to permanent pasture it was only 9 lb per acre. The appropriate averages for England and Wales in 1952 were 17 and 8 lb of nitrogen per acre, respectively.[2]

These figures are not strictly comparable since Scotland was included in the 1957–58 averages, but not 1952, although it appears that there was only a slight increase in the *average* application of fertilizer nitrogen to grassland. This reflects the fact that in 1957–58 considerably less than half the leys (43 per cent), and only 28 per cent of the permanent pasture, received any nitrogenous fertilizer at all. Apparently the longer leys received heavier dressings of nitrogen than one-year leys, and grazed leys received less fertilizer than hay or silage leys. Long leys frequently received heaviest dressings in their early years.

Interaction of Clover and Fertilizer Nitrogen

Davies and Williams[3] pointed out that a well-balanced grass/clover sward should be capable of producing 5,000 to 6,000 lb of dry matter per acre per annum without the application of fertilizer nitrogen, but this was dependent upon the management maintaining a high clover content.

In a paper to the 8th International Grassland Congress (where a whole session was devoted to the use of nitrogenous fertilizers on grassland), Green and Cowling[4] considered that a pure grass sward, receiving adequate nitrogen, could produce double this yield. The use of relatively small dressings of fertilizer on grass/clover leys will produce immediate increases in yield, but will also reduce the clover content, so that in the long term net gain may be small.

Influence of Dung and Urine

Articles by Watkin[5] and Wheeler[6] have discussed the results of applying nitrogen to leys in the presence and absence of dung and urine. Nitrogen and urine were the dominant factors affecting botanical composition: nitrogen application increased the percentage of ryegrass and decreased the clover content; the return of urine discouraged the spread of weed grasses. The application of between 260 and 310 lb per acre of nitrogen, in the presence of returned dung and urine, produced 10,000 to 12,000 lb of dry matter per acre per annum from swards in which the management had eliminated clover. These results agree closely with the figures for pure grass swards quoted above.

Nodulation

The influence of nitrogenous fertilizer on the root weight and nodulation of white clover growing in a mixed sward was studied by Young.[7] The general effect of applied nitrogen was to reduce the clover root weight and number of nodules. However, 36 lb of nitrogen applied in the early spring appeared to have a slight beneficial effect on the top growth of clover and also on the number of nodules. Successive applications of nitrogen caused a decrease in the herbage production and root weight of clover, and when 200 lb of nitrogen had been applied there was a significant decrease in the number of large (presumably active) nodules per gram of root.

It was suggested that, with careful management, it should be possible to combine the benefits from clover and fertilizer nitrogen. Thus on grass/clover swards, nitrogen applications should be restricted to early spring and autumn, when clover growth is not very active and nitrogen fixation is low. Other alternatives are to apply large quantities of fertilizer nitrogen to areas of pure grass and no nitrogen to areas of grass/clover mixtures; or to manage leys during their early years to encourage clover growth and to apply heavy dressings of nitrogen in later years as the legume dies out.

Extension of the Grazing Season

One of the obvious uses of nitrogen is to obtain grass growth earlier and later than is normal. If this is combined with hard grazing in late spring, it should be possible, as indicated above, to obtain some of the benefits of both fertilizer and clover nitrogen from the same swards. The effect of fertilizer nitrogen and that of autumn management on the production of early spring grass was studied over a number of years at the Grassland Research Institute and at many centres throughout England and Wales (Baker[8], Baker *et al.*[9]).

Spring Nitrogen and Autumn Nitrogen

The most important management factor influencing spring growth was the application of spring nitrogen, but the earliness and quantity of herbage was very dependent upon the weather. Thus the average increase in grass yields for each year ranged from 6 to 22 lb of dry matter for each pound of nitrogen applied in the spring. The use of fertilizer nitrogen in early September increased herbage yields in the autumn by 8 to 22 lb per pound of nitrogen applied.

Autumn nitrogen did not, however, have any practical effect on the growth of grass in the following spring. Both Italian and perennial ryegrass responded well to autumn nitrogen, but it was important to graze off the extra growth fairly quickly to prevent the sward becoming too open. The yield of ryegrass swards which received nitrogen in the spring was very much higher if they were grazed during the previous

September and October than if they had been rested for the whole of those months.

Generally neither autumn management nor autumn nitrogen had a marked effect on the spring yields of cocksfoot, timothy, and meadow fescue swards. Other workers (e.g., Corbett *et al.*[10]) have shown that valuable winter grazing can be obtained from cocksfoot swards rested from August, which receive at that time about 52 lb per acre of nitrogen. Provided the grazing of winter grass is controlled by paddock grazing or the use of electric fencing there is no detrimental effect on the subsequent spring growth.

Rooting Depth and Irrigation

Experiments by Oswalt *et al.*[11] in America indicate that the roots of cocksfoot penetrate more deeply in the soil if fertilizer nitrogen is withheld than when it is applied. Nitrogen fertilizer increases the diameter of roots but decreases the rate of elongation, so that a shallow rooting and feeding system is obtained.

The roots under a high nitrogen regime appear to be more efficient in nutrient uptake because the herbage yields are greater, although the root systems are shallower and weigh less. This lack of root penetration means, however, that, under dry conditions, the maximum responses to fertilizer nitrogen will not be obtained unless accompanied by irrigation, for the shallow roots will be very susceptible to drought. Thus Munro[12] found that, in Berkshire during 1955, the responses to nitrogen applied in mid-season were very low unless accompanied by irrigation. The application of 370 lb of nitrogen per acre to a grass/clover sward only produced 6,230 lb of dry matter per acre compared with 12,170 lb per acre when 9 in. of water were applied throughout the season.

Quality of Herbage

The effects of different levels of nitrogen application on the nitrate content of herbage has recently been reported (ap Griffith[13]). Mineral nitrate is known to be toxic in its effect on farm animals; little information has been recorded in this country as to its lethal or sub-lethal effects, but the author considers that it would be prudent to regard with suspicion any herbage containing 0·07 to 0·2 per cent nitrate nitrogen.

Six different rates of nitrogen were applied to grass swards in late April (the highest level being 280 lb per acre of nitrogen). Six weeks later the herbage was cut and analysed. There was a linear rise of nitrate nitrogen with increasing rates of nitrogen applied, and the application of 140 lb of nitrogen per acre resulted in a nitrate content of approximately 0·09 per cent, which is within the range quoted by Griffith as possibly detrimental.

The influence of nitrogen fertilizer application on the quality of herbage has been studied by Minson *et al.*[14] They found that, although

the nitrogen caused considerable increases in herbage production, it had little effect on the percentage content of digestible organic matter, so that the yield of total digestible nutrients was considerably increased by nitrogen fertilizer.

Conclusion

The above papers all provide valuable information on the use of nitrogen on grassland. They indicate, however, the wastefulness and danger of using nitrogen indiscriminately; and it is important to emphasize that, not only should nitrogen usage be properly planned, but the resultant extra herbage must be utilized efficiently.

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The Purchased Calf

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IT IS common knowledge that heavy losses occur in the young of all species of farm livestock, whether lambs, pigs, calves, or poultry. The newborn animal has to adjust itself to a new environment, physiologically and nutritionally, and the less favourable the conditions into which it is born the less its chances of survival. This is also, or should be, common knowledge.

There are many factors that have a bearing on the problem of mortality in young animals, and these factors vary with the different species. This variation is linked with differences in the number of young born, in the type or types of housing (if any) and with feeding and other facets of management. For example, one would expect, other things being equal, that a calf would have a better chance of survival than a pig, and certainly under most conditions this is so.

The average cow gives birth to a single calf, which is well developed at birth when its weight is possibly 8–10 per cent of that of the dam; in other words, it is relatively well grown. Given the right conditions, it should readily adapt itself to its new environment. But a sow may give birth to 10 or more piglets which are relatively poorly developed, often weighing but a pound or two at birth. Some of the litter are frequently smaller and weaker than others. The piglets are in competition for the milk of the dam and quite often the result is that the weaker succumb and die.

Influence of Environmental Conditions

Yet despite the obvious biological advantages of the calf, the environmental conditions into which it is born are often such that in many individual herds the heifer calf mortality may reach 25 or 30 per cent, while surveys have shown an overall mortality rate in heifer calves of around 6 per cent in England and Wales and 11 per cent in Scotland; and this among home-bred calves.

These surveys have shown that the greatest mortality and sickness among calves occurs in the early spring (February to April inclusive). Most deaths occur at a very early age, i.e., during the period when the calf is attempting to adjust itself to its new environment. Thus nearly half the losses occur in the first week, two-thirds within a fortnight, and three-quarters within the first three weeks.

PROTECTION BY COLOSTRUM

It is evident from these survey findings that calf losses vary from farm to farm and season to season, even among home-bred calves. Nevertheless these calves have usually some advantages and therefore a better

chance of survival than calves that are sold off the farm for rearing elsewhere. It is accepted that the first milk (colostrum) of the dam is of great importance in the protection of the newborn calf against early post-natal infection. But this protection operates only against the micro-organisms present in the environment into which the calf is born. If the calf is removed to a different environment, as happens when it is sold to another farm for rearing, the microflora may be of a different kind against which the antibodies derived from the colostrum may give it no, or at the most only partial, protection.

Much Loss is Preventable

The chief causes of death in home-reared calves are septicaemia, white scour and nutritional diarrhoea, which collectively account for no less than 40 per cent of the total post-natal sickness. Much of this loss undoubtedly is due to faulty methods of husbandry and is therefore preventable. But if attention to the details of management is necessary to rear calves successfully in the environment in which they are born, it becomes of even greater importance when calves are moved to a new environment.

One may suppose, however, that standards of management and methods of rearing vary as much on rearing farms as elsewhere. Because calves imported on to such farms are already at some disadvantage as compared with home-reared calves, it is not surprising that reports show a higher morbidity and mortality rate among them. This has become very evident during the last few years, during which period the practice of buying-in calves for rearing has increased considerably.

Moving purchased calves from one farm to another is only one of the reasons why the death rate tends to be higher than in home-reared calves. The means by which calves are obtained and transported to the rearing farm are quite as important to success as, for example, the way in which they are subsequently fed. Since the animal is at the most susceptible period of its life, the less risk to which it is exposed during this period the better.

DIRECT TRANSPORTATION IS BEST

Ideally, calves should be purchased from a single herd and moved directly to the purchaser's premises. In such cases it should be possible to ensure with the breeders that the calves receive colostrum from their dams, so that they have some degree of protection. If the calves are bought from a number of farms, direct transportation is still the method of choice, but the rearer should avoid mixing bunches of calves purchased from different sources; they should, if practicable, be reared in separate units.

While this method of purchasing and transportation is the ideal, it is the exception rather than the rule. More commonly, the origin of purchased calves is obscure. Some rearers rely on dealers to supply their

needs. Calves bought in this way may have had a number of temporary homes en route to the purchaser, viz., farm of origin to market—market to dealer's premises—dealer's premises to rearer. This method of purchase may save the rearer the trouble of arranging direct with a breeder for a supply of calves and for their transportation, but its dangers far outweigh these considerations, because calves obtained in this way tend to suffer the highest losses.

EXPOSURE TO INFECTIONS

Apart from such factors as the stress and strain of a number of journeys, and interruption of adequate and appropriate feeding, the most important reason for these serious losses is the exposure to infections which calves commonly suffer.

It is necessary to appreciate how infective agents can be transmitted from one animal to another; in this the time factor is important. All calves acquire a variable microflora soon after birth, and on occasion this microflora may contain an infective agent which is capable of causing illness and death. If calves are gathered together from a number of sources, the chances of a calf being purchased which is infected with such an organism increases in direct proportion to the number of farms from which the calves are obtained.

Further, when a bunch of calves is brought together in this way, the number of them that may become infected with an organism of this kind is again proportional to the length of time the calves are kept together. Hence one infected calf may give rise to a widespread infection in the bunch. Let us assume that the organism is of a kind which is excreted in the faeces or via the respiratory tract. An extensive infection in the bunch will cause heavy contamination of the building in which they are housed. Unless adequate disinfection is subsequently carried out, the next bunch of calves housed in the same building is exposed to a high infection rate. Over a period of time, this may mean a succession of bunches of calves becoming infected before reaching their ultimate destinations, i.e., the rearing farms.

ILLNESS MAY NOT BE VISIBLE

Therein lies the danger of purchasing calves by a method which involves their having one or more ports of call between the farm of origin and the rearing unit. The calves may be infected on arrival, but the incubation period may be such that they may not become visibly ill until later. Indeed, they may not become visibly ill at all. Whether they do so will depend on factors partly within, and partly without the rearer's control.

If, for example, the calves received a sufficiency of colostrum from their dams—something which, with calves bought through a dealer or market, is without the rearer's control—they may resist the infection. On the other hand, factors within the farmer's control may precipitate the onset of illness. Among these are included the method and efficiency

of rearing, e.g., system of feeding, housing (warm and dry as opposed to cold and draughty) and perhaps most important of all, the degree of attention given to the calves.

Care and Attention to Detail

Although successful calf rearing is a skilled job demanding considerable care and attention to detail by the attendant, it is too often added to the duties of an already hard-worked cowman. Methods of calf rearing cannot be included here; it is sufficient to say that there are a number of methods which prove successful in skilled hands.

The special hazards mentioned earlier, to which purchased calves are exposed explain why their chances of survival tend to be rather less than homebred calves. Because of these hazards—in particular purchased calves held together for variable periods of time at different premises en route to the rearer—the causes of illness and death among them tend to differ in degree from those causing losses in home-bred calves.

Thus, whereas in the latter septicaemia, white scour and nutritional diarrhoea were found to be collectively responsible for some 40 per cent of the total post-natal sickness, a survey at present in progress suggests that following the increase in the practice of buying calves for rearing, infections alone account for some 50 per cent of the total loss. Furthermore, there now appears to be a high incidence of loss in the 2–4 weeks old age group.

Reducing Losses

What can be done to reduce these losses? The answer lies very much in the rearer's own hands, and among the more important steps that can be taken to reduce the risk of morbidity and mortality are the following:

1. Try to buy calves from one source.
2. Arrange for their transport under reasonable conditions direct from farm to farm.
3. Buy calves in groups and not a continual trickle of small numbers.
4. Make a clean break between successions of batches of calves to permit thorough cleansing and disinfection of buildings.
5. Give the calves nothing but water and glucose for the first 24 hours after arrival.
6. House in well-ventilated buildings with plenty of straw on the floor. Barns with straw bales as draught protection and plenty of straw bedding, connected to an open yard, are quite suitable.
7. Give personal attention for at least a week after arrival and preferably feed three times a day.
8. Keep different age groups in separate units.
9. If the type of housing and the weather appears to warrant it, use infra-red lamps to supply heat.
10. If one or more calves become ill, remove the remainder to other accommodation, splitting them up into as small groups as possible.
11. Don't think that by adding drugs of various kinds to the diet that you have a panacea for all ills. Drugs have their place in the treatment of specific infections but they cannot be expected to cure the ills of bad husbandry.

Farrowing Pen Design

F. J. W. WINSHIP

Agricultural Land Service, Northern Region

WITH THE decreasing margin of profitability following the immediate post-war period, a detailed examination of production costs in the pig enterprise has been forced upon farmers. Farm accounts have been systematically analysed to ascertain where economies can be made, with the result that attention has been drawn to the basic production unit—the sow.

The cost of keeping a sow over a period of a year remains reasonably static, even when due allowance is made for the food consumed by the piglets prior to weaning; therefore the greater the number of piglets weaned the less would be their cost of production. Since man has no direct control over the numbers born, it is evident that those born should be given every chance of survival.

Chances of Survival

Most losses are caused by the sow crushing the young pigs and, as an immediate remedy, many ingenious ideas have been put forward to keep the piglets out of harm's way. Only during the past ten years has it been generally realized that the primary cause was the climate within the farrowing structure. Newly-born pigs have poor powers of heat regulation. Should they be presented with an unfavourable environment (low air and surface temperatures within the building) causing excessive cooling of their bodies, they will not achieve their normal body temperature and consequently will remain in a sluggish condition and be prone to "over-lying". Of course, if the conditions are particularly adverse they will die.

Design

From the original outdoor ark design (which still has its place on the small farm, or where a "natural" break is desired between the farrowing house and an intensive fattening unit) and the simple pen with creep and farrowing rails, rapid developments have now taken place. Recent designs include sufficient insulation and controlled ventilation to give a background temperature of 55°F, which is low enough to prevent the sow being distressed, yet, at the same time, provides a satisfactory climate for active piglets of a few days old. Supplementary heat, normally an infra-red lamp, is always provided in a separate compartment for the piglets to ensure that they sleep with an air temperature of 75°F, which is gradually reduced between three and eight weeks. An infra-red lamp has the added advantage of attracting the young pigs away from the movements of the sow.

Great attention has been given to the pen layout to ensure ease of management. However, to combat the high capital cost of these designs, the surface area per sow has been greatly reduced, in fact in some cases halved, with the further advantage of relatively increasing the quantity of heat available for warming the building.

Although there are over twenty designs existing in the United Kingdom, they are based on three main types—Scandinavian, Scottish, and New Zealand.

SCANDINAVIAN LAYOUT

This is, basically, a double row of pens (the size of pen being approximately 10×10 ft) divided by a 4 ft wide central passage. Permanent troughs and rails are situated along the central passage since the building is primarily for fattening pigs. Along the rear of each row of pens there is the normal dunging passage. For farrowing purposes a removable crate is bolted inside the pen to confine the sow to a limited area. The surplus space is utilized as a creep for the young pigs. The total area per sow and litter is about 140 sq. ft.

An English version of the Scandinavian layout has been erected by British Oil and Cake Mills at Hobbs Cross, Essex, and has been in existence for eight years. As an alternative to the farrowing crate, the sow has the freedom of the pen, which is approximately 8×8 ft and the young pigs lie in a creep formed by raising the centre passage. The total area per sow and litter is about 110 sq. ft.

SCOTTISH LAYOUT

Within a well-insulated building there is situated longitudinally a range of farrowing stalls, alternating with pairs of low walled creeps, the whole being of permanently fixed construction or of removable timber units. Each stall measures 8×2 ft and the front portion of the stall, within which the sow is confined, is only 6 ft in length. Such confinement prevents her turning round and encourages her to remain lying on clean bedding for the greater part of the 24-hour day, thus almost eliminating deaths due to over-lying. The total area per sow and litter is about 75 sq. ft.

NEW ZEALAND LAYOUT

This was developed by the Ruakura Research Station, with the intention of preventing the sow from crushing the piglets. A round structure 8 ft in diameter was set within a normal-size pen, within which was another round structure, 3 ft in diameter, where the piglets could lie unmolested. The structure was of such design and proportions as to induce the sow to lie with her teats towards the centre, thereby permitting the piglets to suckle without having to leave their protective shelter. The total area per sow and litter is about 140 sq. ft.

Layouts Compared

The table below represents the author's attempt to compare the relative merits of the three basic layouts, plus the B.O.C.M. house, taking into account the following four factors:

1. environmental conditions, i.e., temperature, humidity, surface temperature;
2. ease of management, feeding, cleaning and general supervision;
3. economy in cost and ease of conversion to another purpose;
4. measure of success in saving piglet losses.

It should be borne in mind that the figures awarded out of a maximum of ten are not absolute but merely comparative. It has been assumed that similar insulation materials have been used and the ventilation rate is the same in all designs. The level of management, which is not constant, would have an appreciable influence on the piglet losses and therefore the figures relating to item 4 should be treated with some reserve.

	1 Environmental conditions	2 Ease of management	3 Cost and ease of conversion	4 Losses prevented
Scandinavian	6	8	9	7
B.O.C.M. (Hobbs Cross)	8	8	8	8
New Zealand (Ruakura)	6	5	7	7
Scottish	9	9	6	9

Conclusion

The above figures can only indicate inherent qualities of the designs selected or the attitude of the designer to the problem. For example, in Scandinavia initial cost and ease of conversion have obviously been given priority over the environmental conditions, whereas the converse is true with the Scottish design. It would seem that an improved design would lie somewhere between these points of view. This fact can be borne out by the designs now being recommended in both Denmark and Scotland, which are very similar in layout. When the Ruakura type is assessed under British conditions it appears not to have great merit, but it must be remembered that this design is still vastly superior to the average farrowing pen existing in the United Kingdom. Although the latest Australian research indicates that the farrowing stall (Scottish and Scandinavian) is superior to the Ruakura, there is insufficient evidence on which to condemn the latter design.

The choice of a particular design would be governed largely by the size of the sow herd. On a small unit where adequate individual attention can be given, the Ruakura layout could be successfully operated

(particularly when it is operated under an outdoor system). For the very large unit, the Scottish layout has obvious advantages, especially when early weaning techniques are employed.

For the future, the trends are towards adopting the farrowing stall principle in a well-insulated and ventilated building with a layout permitting easy conversion and, in total, costing no more than £150 per sow.

Such a design would have considerable advantages for the farmer with a small pig enterprise. He can have the advantages of "maternity" conditions if he wishes to raise his own weaners, or he can convert the whole building to a fattening house overnight by removing the appropriate stall divisions (and increasing the ventilation rate).

The suggested plan shown on pages 156 and 157 is basically a single- or double-range Scandinavian layout with complete division (with the exception of pop holes) between dunging and sleeping areas. The structural insulation should have an overall value not worse than 0·15 B.t.u./sq. ft and the ventilation should ensure that the flow of air passes from the sleeping to the dunging area.

There are four possible variations to the same basic plan, which together form a logical sequence:

1. two removable solid sides A and B in position to give "crate-like" conditions for farrowing and the first ten days of the young pigs' life;
2. side B removed giving the sow greater freedom yet giving the young pigs a small creep for supplementary heat and feeding;
3. side A removed and side B replaced allowing the younger pigs greater freedom from 4–8 weeks;
4. both sides A and B removed, allowing the pen to be used for rearing and fattening.

Note. At all times (except during the actual period of farrowing) the sow and young pigs have access to the dunging passage.

ACKNOWLEDGMENT

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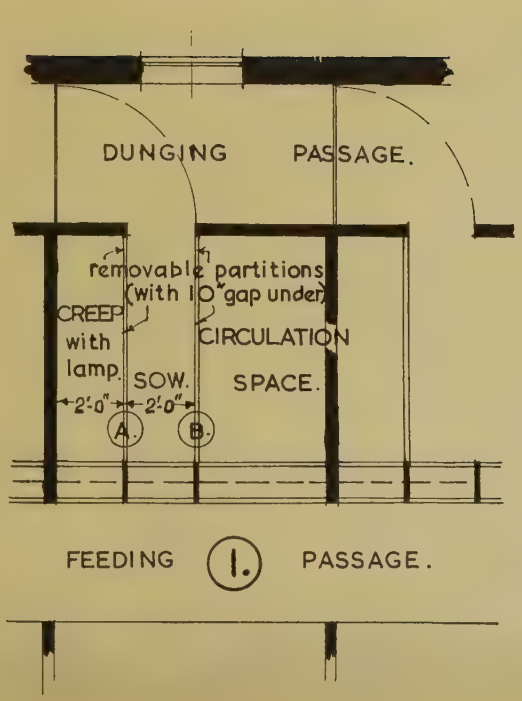
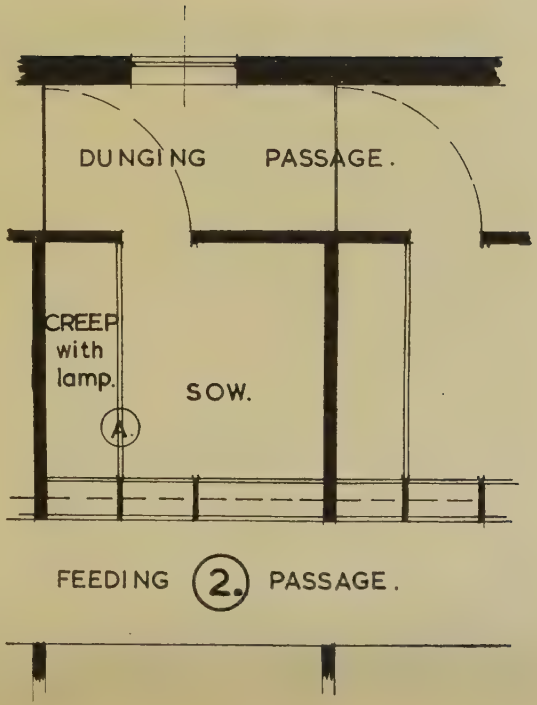
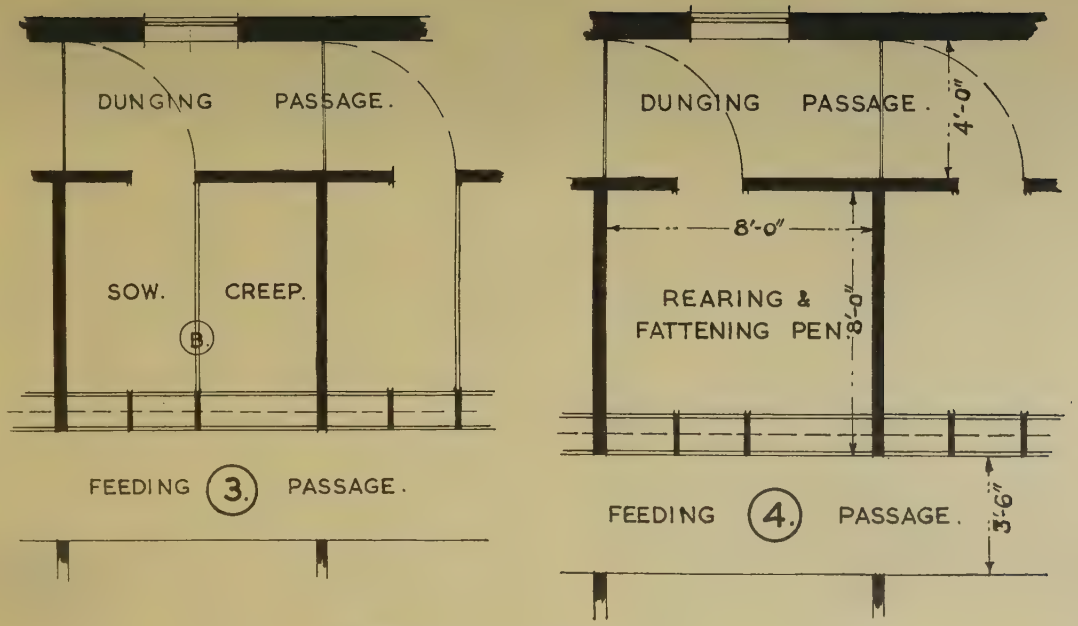

DUNGING PASSAGE.
removable partitions (with 10" gap under)
CREEP with lamp.
CIRCULATION SPACE.
SOW.
2'-0"
2'-0"
A.
B.
FEEDING 1. PASSAGE.


DUNGING PASSAGE.
CREEP with lamp.
SOW.
A.
FEEDING 2. PASSAGE.



Suggested design for adaptable farrowing pen.

Planning Labour Use on Arable Farms

E. S. CARTER and T. W. NICOL*

National Agricultural Advisory Service, Lincolnshire (Lindsey)

IT IS becoming increasingly evident that the attitude of the farming community—at any rate in north Lindsey—towards farm management is changing rapidly. Farmers are actively demanding management advice, and in nearly every case much more than general analysis of farm accounts is called for.

The adviser himself must develop new techniques of analysis, interpretation and presentation of the results to the farmer. The actual method will vary in different parts of the country, depending on the items that have most importance. One such technique is that of programme planning, recently discussed by G. B. Clarke and J. White.[1]

Another tool in management advice is that of planning the use of labour over the year and the correct application of mechanization. The system described in this article has been developed from work carried out at Cambridge University School of Agriculture by F. G. Sturrock, D. B. Wallace and T. E. Godsell.[2]

Influence on Costs and Profits

The need for this approach has arisen because on arable farms in Lindsey some 33 per cent of the total costs are accounted for by the wages of regular and casual workers. Add machinery costs and the two together make up more than 50 per cent of the total. Farm wages increased on 1 January 1961, and machinery costs continue to rise at a steady rate each year. These two items, which may be considered interchangeable as a means of getting work done, are of first importance in farming operations. Clearly, any reduction that can be achieved in these costs will exercise a big influence on overall costs and farm profits.

HIGH EXPENDITURE IN RELATION TO OUTPUT

More than 60 per cent of cases dealt with by the authors showed that expenditure on these items was too high in relation to the output being achieved. In the past it has been possible to maintain income by raising output and thus reducing cost per unit. This is no longer the easy answer; on the better class of arable farm it is still possible to push up output, but it becomes increasingly difficult. Where it is possible, the effect is often to complicate the farming system, increasing management difficulties out of proportion to the possible gain. Table 1 shows the effect of this on a large arable farm.

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* Now National Agricultural Advisory Service, Hampshire.

Table 1

	1958 £	1960 £
Total production per acre	54·7	64·3
Total costs per acre	42·8	50·5
Net farm income per acre	11·9	13·8
Labour and machinery per acre	22·7	27·5
Net output per £100 labour and machinery	212·0	194·0

Increased output is also likely to reduce still further the market prices of individual commodities. What is essential in present circumstances is to tackle the costs of running the farm and try to find ways to reduce them. How is this to be achieved in practice?

Systematic Checks

The standard approach in Lindsey on arable holdings involves the use of four systematically applied checks on the three most recently available sets of farm accounts: (1) a rough calculation at the time the farmer submits his accounts to see if the total output is approximately three times that of the labour bills: failure to meet this standard could be due to low output or to high labour costs or both; (2) normal full analysis of the accounts, with (3) a close study of net output per £100 of labour and net output per £100 of labour and machinery; and (4) a check on the efficiency of labour use by a standard man day calculation on the farmer's crop figures, using data from "The Farm as a Business", Table M.3 (page 161) with local additions and adaptations where necessary.[3]

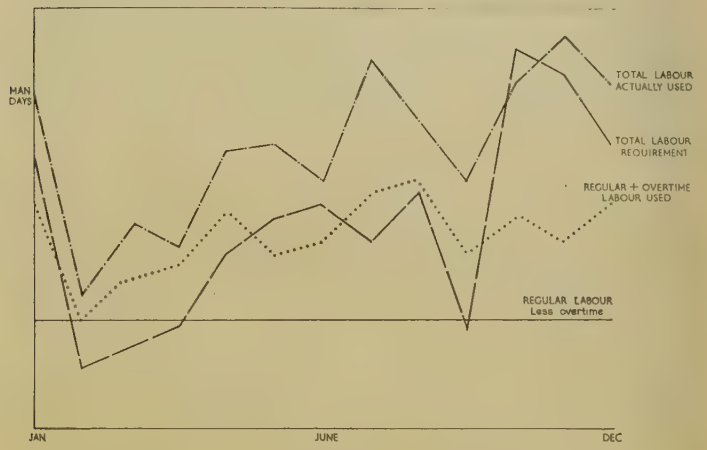
ACHIEVING ECONOMIES IN PRACTICE

Having presented the farmer with these findings his usual reaction will be to ask how in practice he is to achieve economies in labour and machinery use. We have found that the next stage must be to examine the demand for labour in much more detail. The theoretical labour requirement must be broken down to a month by month basis throughout the year, using Table M.5 (page 162) from "The Farm as a Business". This detailed examination will reveal peak demands at certain periods. At this stage the cost of regular labour must be separated from that of casual and an assessment made of the amount of overtime paid to the regular workers. In practice, it has been found that the best way to present this information clearly to the farmer (and to the adviser) is to prepare a graph (see below).

The one illustrated is of data from a typical 800 acre north Lindsey arable farm. It clearly shows the fluctuation of the total labour requirement expressed in man days and is the usual pattern obtained for farms in this area.

Regular labour available on the farm is shown as the horizontal line

and the amount of overtime and casual labour actually employed is superimposed. The correlation between total labour use and the theoretical demand is immediately obvious; each month can be studied individually and in detail. The graph could also be used to decide the optimum level of the regular labour force as it is easy to see the period and the magnitude of peak demands. In addition it is of considerable value in forward planning as changes in labour demand and their relation to available labour can readily be seen.



THE ADVISER'S RECOMMENDATIONS

Two courses are generally open to the adviser—one is to study how mechanization can be used to overcome the difficulties associated with the present system of farming; that is, to reduce the demand for labour at the peaks in the graph by intelligent use of machinery. Difficulties in obtaining casual labour and problems of management make the farmer extremely receptive to this course of action and the adviser must be on his guard against over-mechanization. This involves the close and full co-operation of the County Machinery Adviser to ensure that the best possible result is obtained.

The second alternative is to so alter the farming system as to remove or lessen the peak demands for labour. The authors have found that, in considering alternatives to the existing policy, the best results have usually been obtained by reducing the number of end products and streamlining the farming system. The farmer is then able to concentrate on fewer items and give more time to solving the problems of management.

This can be illustrated by the example of a 170 acre farm on heavy

land where, by concentrating on fewer crops and actually reducing production, it has been possible to reduce labour and machinery costs, simplify management, and raise farm income substantially (see Table 2).

Table 2

	1955–56	1956–57	1957–58	1958–59	1959–60
Output £'s per acre:					
Cattle	7·9	5·3	8·5	8·0	6·1
Pigs	3·6	3·1	2·0	2·7	—
Poultry and eggs	2·7	2·0	3·4	9·3	11·6
Wheat and barley	16·5	15·2	12·4	10·1	18·2
Potatoes	4·0	3·1	—	—	—
Peas	5·5	1·2	0·7	—	—
Other crops	3·8	2·0	2·5	—	—
Other income	0·2	0·2	0·6	—	0·1
	44·2	32·1	30·1	30·1	36·0
Costs £'s per acre:					
Paid labour	11·6	9·4	7·7	5·6	4·3
Contract work	0·8	1·5	0·9	1·2	2·3
Power and machinery	8·1	7·7	4·0	5·1	5·9
Purchased food	8·1	2·4	3·9	4·8	9·8
Seeds	3·9	4·0	2·0	2·0	2·0
Fertilizer	4·0	2·6	3·6	2·5	2·8
Rent and rates	1·7	1·6	1·4	1·3	1·3
Other costs	2·2	1·8	1·3	1·1	1·9
	40·4	31·0	24·8	23·6	30·3
Net Farm Income*:	3·8	1·1	5·3	6·5	5·7

* This term is defined on page 18 of "The Farm as a Business" *op. cit.*

Summary

Experience shows that labour and machinery costs are critical in the make-up of the cost structure in arable farming. Farm management techniques will pinpoint weaknesses but are not sufficient to enable a detailed examination to be made of these items. The methods outlined above have been successfully employed on a number of farms with satisfactory results. In practice the solution has been found to be either streamlining the farming system and reducing the number of end products or the mechanization of the peak demands for labour or a combination of both.

References

1. Clarke, G. B., and White, J. *N.A.A.S. Quart. Rev.*, 1960, No. 49, 1–7.
2. Planning a Farm for Higher Productivity. University of Cambridge, *Farm Economics Report*, No. 41.
3. The Farm as a Business. H.M. Stationery Office, London.

A Simple Guide to Feeding Efficiency on Small Dairy Farms

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SMALL FARMS must necessarily be farmed intensively; having few acres they are saddled with high fixed costs per acre, and a high output is necessary if there is to be a reasonable chance of making a good profit.

Some farmers achieve a very impressive output, but do so at high cost. At the other extreme, there are those who have such a remarkable ability for keeping down costs that they can obtain a comparable profit with a very much lower output. For this reason, the relationship between output and profits is not always a very close one, but there is, nevertheless, a definite tendency for high profits on small farms to be associated with high output, and *vice versa*. If we look, for example, at the results for 1959–60 of 45 lowland dairy farms all under 100 acres in Wales, we find that they can be grouped as follows:

Level of output per acre	No. of farms	Average profit per acre
		£
Under £40	6	0·2
£40 to £50	9	9·0
£50 to £70	14	12·8
£70 to £90	10	15·0
Over £90	6	21·3

High Output Important

For farms such as these, therefore, a high output is still an important economic consideration, at least for the individual farmer. The land must be heavily stocked with high-producing animals, and to this end a high standard of grassland management must be aimed at. But however productive the leys and however liberal the use of fertilizers, the restricted acreage of the small farm means that a sufficiently high output cannot be obtained without heavy additional purchases of feedingstuffs. Moreover, a substantial part of higher outputs can only come from pigs or poultry which make little use of land and are almost entirely dependent on purchased concentrates.

On small farms, therefore, efficiency in the use of purchased feeds is relatively a far more important factor of success than a high standard of grassland management, although, of course, good grass can result in economies in feed purchases which are still substantial. On the majority

of dairy farms, up to say 60 or 70 acres, the cost of purchased feed is more than all other costs put together.

Consequently, it is extremely valuable to have a guide to overall efficiency in the use of feedingstuffs when studying the management of the small dairy farm. A frequently used measure is the value of farm output per £100 spent on feedingstuffs, but this is a very poor guide for the simple reason that it takes no account of the level of output. We have already emphasized that high profit is associated with high output, and the farmer who obtains a high output through using more feedingstuffs will usually have a lower total output per £100 spent on feedingstuffs than farmers who use much less, although the eventual profit will frequently be higher. This can be illustrated from the sample of 45 Welsh dairy farms previously referred to. In order of profitability per acre the top third of these farms had an average output per £100 spent on feedingstuffs of £254, compared with £281 for the next one-third of the farms.

Average Relationship between Feedingstuffs and Output

A more useful rough guide to the average relationship between feedingstuffs and output for most small dairy farms, at least in Wales and probably for other parts of the West, can be expressed as follows: the gross output in £ per acre should equal $1\frac{1}{2}$ times the cost of feed purchases per acre plus £26. For example, if on a farm of 50 acres the total amount spent on purchased feed is £1,000, or £20 per acre, then a reasonable estimate of the gross output that ought to be obtained on average is $(1\frac{1}{2} \times 20) + 26 = £56$ per acre.

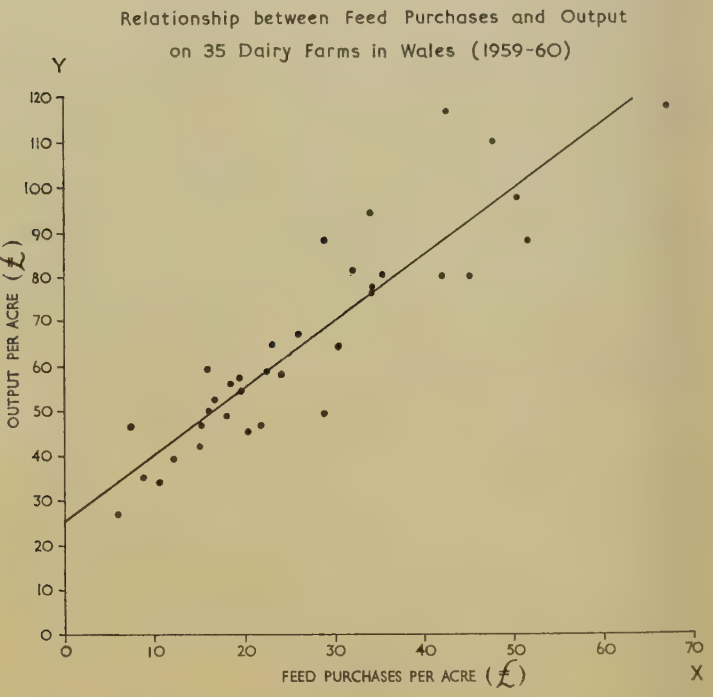
This measure derives from the fact that, if gross output per acre is plotted against feed cost per acre, the resulting points for small dairy farms fall very closely along a straight line. This is illustrated in the graph overleaf which relates to 35 dairy farms on better class land in Wales. All the farms are between 25 and 90 acres, and the figures used for each farm are an average of the two seasons 1958–59 and 1959–60. As it happens, the line which best fits the points for this small sample of farms is almost identical with the rough measure suggested above.*

Since there is a close correlation between output and feed purchases (for this sample $r = +0{\cdot}9$), the expected level of feed purchases for a known level of output can be roughly estimated by transposing the formula for estimating output from the level of feed purchases. In other words, we can say either

(a) Gross output per acre = $1\frac{1}{2}$ times feed purchases per acre plus £26, or

(b) Feed purchases per acre = $\frac{2}{3}$ gross output per acre minus £26.

* The equation of the line fitted by least-squares was actually $Y = 25{\cdot}24 + 1{\cdot}508\ X$.



Actual and Estimated Purchases of Feed

Applying the second formula to 45 lowland dairy farms of under 100 acres in Wales, arranged in three groups according to their level of profits per acre, we get the estimated requirements of purchased feed shown in the following table. The highest profit group used 10 per cent less purchased feed than estimated "average" requirements, the second group about 6 per cent less, whereas the lowest-profit farms used about 40 per cent more. The last column shows that the same conclusions about the relative efficiency of these farms in the use of feedingstuffs could not be deduced from the value of the gross output per £100 feed purchases.

Possibility of Wider Application

It must be emphasized that the formula suggested here for making a rough assessment of efficiency in the use of feedingstuffs on small farms applies particularly to Welsh lowland farming conditions and that it may give estimates which are too low for more favourable areas of

England. A cursory examination of the standards provided for advisory work in some other areas, however, suggests that the formula may have wider application than just in Wales.

For example, standards provided by Manchester University for output and feed purchases on dairy farms under 100 acres on moderate

Table 1

Actual and Estimated Purchases of Feed on Lowland Dairy Farms under 100 acres in Wales in 1959–60

Order of profitability per acre	Average profit £/acre	Gross output £/acre	Feed Purchases			Gross output £ per £100 feed purchases
			Actual £/acre	Estimated £/acre	Actual as % of estimated	
Highest one-third	23·8	76·8	30·3	33·8	90	254
Middle one-third	10·8	59·9	21·3	22·6	94	281
Lowest one-third	2·0	48·6	21·1	15·1	140	230

Table 2

Output and Feed Purchases on Lowland Dairy Farms under 100 acres in NW England 1958–59

	Average			High profit		
	Gross output per acre	Feed purchases per acre	Estimated requirements of purchased feeds	Gross output per acre	Feed purchases per acre	Estimated requirements of purchased feeds
	£	£	£	£	£	£
1. Farms with less than 10 livestock units of pigs and poultry per 100 acres	51·6	18·5	17·1	68·8	27·0	26·0
2. Farms with 10–30 livestock units of pigs and poultry per 100 acres	79·6	35·3	35·7	75·2	29·1	29·8
3. Farms with more than 30 livestock units of pigs and poultry per 100 acres	137·6	71·4	74·4	125·3	62·3	60·0

to good land in north-west England are shown in the table below. For comparison, columns have been inserted showing estimated requirements of purchased feed derived by the formula. For the "high profit" standards the estimates as derived are reduced by 10 per cent.

Considering the very wide range of intensity of production encompassed by these standards, it is thought that the formula gives reasonably close estimates and that under appropriate conditions, therefore, it can provide a useful first step in the analysis of feeding efficiency, and may be helpful in providing a guide to the probable level of feed purchases in budgeting farm plans.

Herbicides for Daffodils and Tulips

JAMES WOOD and F. W. SHEPHERD

Kirton Experimental Husbandry Farm — *Rosewarne Experimental Horticulture Station*

TRIALS OF herbicides, to assess their value for use on bulb crops, have been in progress at Kirton for over ten years and at Rosewarne for seven years. During this time observations on commercial holdings have also added considerably to our knowledge of the subject.

Factors which Encourage Weeds in Bulb Crops

The leaves of daffodils and tulips do not completely cover the soil, and thus allow many weeds to grow unchecked by the smothering effect by which certain other crops keep the weed population in check.

Both crops emerge in the winter or early spring, and thus prevent pre-emergence cultivations from being used to control the crop of spring weed seedlings. Furthermore, these crops are normally planted close together, and having easily damaged foliage, no inter-row mechanical cultivation is possible; the hand hoeing and weeding formerly used is now too costly. These factors have tended to make daffodils and tulips (and other bulb crops) extremely "weedy" often with a great variety of weed species.

Species of Weeds

The species present tend, of course, to vary from soil to soil with the climate. Those found most frequently at Kirton and in the eastern counties include chickweed *Stellaria media*, speedwell *Veronica* spp., groundsel *Senecio vulgaris*, annual nettle *Urtica urens*, shepherd's purse *Capsella bursa-pastoris*, fat hen *Chenopodium album*, knotgrass *Polygonum aviculare*, mayweed *Matricaria maritima* spp. *inodora*, bindweed *Convolvulus arvensis*, and annual meadow grass *Poa annua*.

Several of these occur at Rosewarne and in the west, while redshank *Polygonum persicaria* and other polygonums, the rayless mayweed

Matricaria matricarioides and grasses such as creeping bent *Agrostis stolonifera* and annual meadow grass *Poa annua* are also found. An even wider range of weeds is to be found in the bulb fields in the Isles of Scilly.

There is a considerable volume of knowledge about the control of most of these and other weeds,[1] but much less is known about the effects of the successful herbicides on bulb crops. The trials at the experimental centres were therefore not only designed to obtain a kill of the weeds present, but to provide information about the effect of the herbicides on the crops.

Trials of Pre-emergence Weedkillers

When the trials were started at Kirton, sulphuric acid and vaporizing oil were the only herbicides regarded as suitable, even for restricted use, as pre-emergence applications on beds of daffodils and tulips. These materials killed existing weeds except grasses, but did nothing to prevent other weeds growing from seeds already present in the soil.

In the first trials DNC, MCPA, and 2, 4-D were tested, with sulphuric acid as a standard. None was found suitable for post-emergence use and none, except DNC, had any greater value for pre-emergence application than the standard.[2]

The next series of trials at Kirton compared various rates of application of DNC, dinoseb, and PCP emulsion, with sulphuric acid again as a standard. It was only at the highest dosages that a satisfactory control of weeds was obtained. Cost, hazard to the crops, and risk to the operator made DNC and dinoseb far from satisfactory, and they were excluded from further trials. Sulphuric acid, applied at the rates necessary for effective weed control, is also quite costly, and it does not control the grasses except when applied to very young seedlings in dry weather.

When sodium arsenite became available it was used at Kirton and on farms in the eastern counties, and gave excellent weed control at a cost much lower than that of any other pre-emergence treatment. This substance became popular in that district, and for several years it replaced sulphuric acid as the standard pre-emergence treatment, giving valuable control of weeds, until it was withdrawn because of its poisonous nature. However, in trials at Rosewarne,[3] sodium arsenite did not give such satisfactory results, mainly because the heavier rainfall quickly washed the substance out of the surface soil and thus rendered it less effective in such conditions. PCP was found to be more effective, and for a time was widely used in the district.

Translocated and Residual Herbicides

These first herbicide trials at Rosewarne, and similar ones at Kirton, were arranged in collaboration with the A.R.C. Unit of Experimental Agronomy, Oxford, who supplied a number of what were at the time new herbicides. In this way TCA, monuron, and chlorpropham were

tested as pre-emergence sprays, together with a number of others already in use.

TCA is intended to control various grasses and did so effectively. But in the second flowering season after application, it was observed that the flower buds of narcissus failed to open and were deformed, although in the first flowering season following treatment the flowers had been normal. Moreover, once such deformity of the flower had become evident it recurred annually to a lesser degree for several years; the period of recovery depended on the dosage of the herbicide that had been applied.

In trials at Kirton (see Table 1), monuron at 4 lb/acre in 100 gal/acre of water gave good control of weeds except speedwell, but it severely injured tulips and reduced bulb yield; on daffodil beds the crop was less severely affected but the variable results were sufficient to justify exclusion of this herbide for use on both daffodil and tulip crops.

Chlorpropham was, however, very effective on newly-planted beds where weeds had not become established. It also had the desired residual effect sufficient to keep the beds clean for several months at a dosage of 4 lb/acre. Unlike the contact herbicides which scorch weeds quickly, the residual types are slow acting to start with, and the assessment of crop injury from pre-emergence application is more difficult than with contact herbicides. Where visible injury is severe, as with monuron, the foliage dies prematurely. Crop yields were recorded as an aid to injury assessment and are shown in Table 1.

On beds of narcissus King Alfred[4] the treatments were applied in

Table 1

Pre-emergence Weedkillers on Narcissus and Tulip Beds
(Yields as percentage of Unweeded Plot Yield)

Treatments applied as pre-emergence sprays mid-December	lb/acre in 100 gal/acre water	Narcissus: Bath's Flame (weight planted per plot 84 oz)	Tulip: Rose Copland (weight planted per plot 42 oz)
		Weight lifted as percentage of control yield	Weight lifted as percentage of control yield
Unweeded (control)	—	100·0	100·0
Sulphuric acid 12·5 per cent	—	119·0	119·5
PCP emulsion	16	121·6	125·3
DNC	12	125·9	113·5
Dinoseb	8	124·8	117·2
TCA	10	97·7	96·7
Monuron	4	114·8	96·9
Chlorpropham	4	123·5	116·4
Chlorpropham	8	128·1	109·2
Handweeded once	—	123·7	121·2
Surface cultivation	—	122·7	120·3

two consecutive years and similar comparative yields were obtained. Subsequently the limitations of chlorpropham became evident[5] and investigations of other residual herbicides were commenced.

Possibilities of Chlorpropham for Post-emergence Use

The residual properties of chlorpropham were outstanding and made its trial for post-emergence use imperative. The results of the trials which were then laid down in 1957 are given in Table 2.

Table 2

Pre-emergence and Post-emergence Weedkillers on Narcissus and Tulip Beds

(Yields as percentage of Unweeded Plot Yield)

Treatments (lb/acre) applied in 100 gal water/ac.		Narcissus: King Alfred (Wt. planted per plot 80 oz)	Tulip: Rose Copland (Wt. planted per plot 33 oz)
26.9.57 Pre-emergence	3.3.58 Post-emergence	Weight lifted as percentage of control yield	Weight lifted as percentage of control yield
Unweeded (Control)		100·0	100·0
Sodium Arsenite ($\equiv As_2O_3$) 9·8 lb	Nil	142·0	119·0
PCP 10·5 lb	Nil	140·0	115·1
Chlorpropham 4·0 lb	Nil	120·0	115·1
Chlorpropham 2·0 lb	+(Chlorpropham 2 lb)	111·6	111·3
Cultivation	+(Chlorpropham 4 lb)	143·0	115·9
Kept clean by cultivation		144·1	104·0

In this experiment at Kirton the results differed according to the crop, those for tulip being less variable than those for narcissus. The increase in narcissus bulb weight was less where chlorpropham 2 lb/acre was applied as a pre-emergence spray. The date of spray application was the same for both crops, but narcissus was planted in early September and tulip in October. Seedlings of mayweed had become established after the earlier planting of narcissus; they were not controlled and grew vigorously. On the plots kept clean by surface cultivation and then given chlorpropham at 4 lb/acre post-emergence, there were comparatively few weeds, but chlorpropham at 2 lb/acre following a pre-emergence treatment of equal quantity had little effect. The best results with chlorpropham were obtained on a clean tilth. As a pre-emergence treatment it should be applied soon after planting has been completed, though it would appear to be more useful following a contact herbicide, but before the weeds have become established.

With a view to obtaining further information about the post-emergence use of chlorpropham, 2 lb/acre was applied on observation plots at both centres when the crops were approaching the flowering period. Tulips were very sensitive and became stunted in growth. Higher dosages caused bleached areas on the leaves and twisting of the flower stalks. On daffodils, brown lesions were present on the leaves where they normally tend to bend over. The absence of injury in the replicated trials (shown in Table 2) seemed to be related to the time of post-emergence application; that is, before tulip leaves have unfurled and before daffodil leaves have begun to separate as they do at about 2 inches in height. For crop safety, therefore, it is better to regard chlorpropham as a late pre-emergence herbicide, and to use it effectively its herbicidal limitations should not be overlooked.

Consideration of Results and Current Practice

Herbicide trials at Kirton and Rosewarne have now become very important items in the programme of experiments with bulbs. They have shown that PCP at up to 8 lb/acre followed by chlorpropham pre-emergence or immediately post-emergence will give good control of annual weeds in daffodil and tulip crops for the greater part of the season from autumn until the following May or June.

The number of new herbicides continues to increase and mixtures of chlorpropham and other herbicides have been and continue to be marketed. Efforts are therefore being made at both centres to keep abreast of developments to enable bulb growers to make full use of herbicides with minimum hazard to their valuable crops, but long term investigations are essential. Kirton and Rosewarne provide a contrast in soil types: one centre is in a locality of low annual rainfall and the other in a high rainfall area. Different environmental conditions affect both the herbicides and plant life, and not least the crop. Herbicides are potent materials, and the wise grower should be aware of the risks he takes before applying them, rather than after.

ACKNOWLEDGMENTS

In long-term investigations there have to be many collaborators to whom thanks are due. We desire to thank all those who have contributed to the results so far obtained.

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"Parish" Meetings

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ANY ACCOUNT of "parish" meetings must be a personal one, because the very essence of these is the personal contact between the D.A.O. and the farmers in his district. The first one I organized was held on 13 December, 1949, and 30 people attended. It was, in fact, an agricultural expansion programme meeting. Having moved around from one county to another, I have on every occasion made a point of asking farmers if they prefer this type of meeting, or whether they would like a set lecture or conference on a larger scale. Without exception there has been an immediate response in favour of the parish type of meeting.

Objectives

First and foremost the idea is to get farmers talking about the queries that arise *in their own minds*. Nearly everyone has some little point, frequently left unanswered at a lecture because he feels it is too unimportant or simple to ask. I have found that farmers with diverse interests like these meetings, and regular attendance ensures a ready-made nucleus for the formation of a discussion society or for "group approach" work of a practical nature where new field techniques can be put over effectively. Being drawn into a discussion rather than merely having questions answered makes a farmer aware of other ways of doing things, and shows him exactly how the N.A.A.S., personified by the D.A.O., can help him.

PERSONAL CONTACT WITH AUDIENCE

Informality is the key, and this depends almost entirely on the D.A.O's personal contact with his audience. He acts more as an M.C. than a speaker, answering some points but inviting those farmers he knows well for their opinions on other topics. His prime responsibility is to keep the discussion going, and especially to bring in those men whom he does not know so well but who show that they are willing to contribute to the discussion.

Normally there is no formal chairman and no votes of thanks. The D.A.O. is the principal; he conducts the meeting and should be encouraged to do it alone. He may sometimes have some assistants, such as a District Committee member or some of his colleagues, but he must *use* these as necessary, maintaining the initiative himself. The use of specialists tends, due to courtesy alone, to restrict discussion to that particular subject, so it is best to use Husbandry Advisers, who cover a wider field.

Invitations should generally be confined to one parish; as small a natural area as possible should be the objective. Any local, warm, comfortable room that is a natural meeting place, with or without a bar (if held in a pub chairs should be arranged so that drinks can be served during the meeting), makes a good venue.

STARTING THE MEETING

Farmers are bad time keepers, so it is useful to have a short film (not more than 10 minutes) or a few slides to introduce local subjects of topical interest. It is important to use these only as talking points; do not attempt a miniature lecture. Aim to cover some 6 or 8 points with perhaps 2 dozen slides in those 10 minutes. I think it is also important to include some well-known local landmark or a scene which will create an immediate interest.

Visual aids, such as examples of crop pests or diseases, bits of badly maintained milking equipment, anything simple and topical, are useful to have on a table in front. They need not be explained in detail, merely a passing reference is all that is necessary to stimulate inspection after the meeting. Choose your aids so as to fit in with the points that you want to get over.

THE DISCUSSION

At most formal meetings a stony silence frequently follows the chairman's request for questions. But at a parish meeting the D.A.O. simply starts the discussion at the point where the slides or film left off. The audience can be asked to put forward any points they would like to discuss, but it is usually better to start by asking a well-known farmer for his views on a subject of which he has a sound grasp.

District Committee members in the audience should be able to fulfil this role and should be briefed accordingly. If the topic chosen does not quite click, it can quickly and easily be changed. It does not take much probing to stimulate a response. It may be hard work in an audience not used to this type of meeting, but even then excellent discussion follows after 10 to 15 minutes of probing. If the atmosphere is still difficult, some really challenging question will usually bring results.

WIDE RANGE OF TOPICS

The subject matter can range over the whole of the Ministry's activities, which illustrates how important it is for the D.A.O. to know what grant and subsidy facilities are available. These need to be referred to when discussing the economics of any subject, detailed queries being handed on to the appropriate department.

With no vote of thanks the D.A.O. will have to close the meeting, and it is better to have a pre-determined time not more than $1\frac{1}{2}$ to $1\frac{3}{4}$ hours from the advertised starting time. Allow a few minutes for discussing whether this type of meeting is liked, and when to have another.

There will always be several farmers who want to examine the visual aids or wish to discuss personal points, so be prepared to stay awhile.

The Invitation

Invitations are best sent out in programme form. The following is an example for a first meeting.

Government Buildings,
Willington Road,
KIRTON.

November, 1959.

Dear Sir, .

This invitation is to a new type of meeting which we have called a "Parish" meeting. Really, it is a very informal discussion arranged to discuss local problems. You can therefore raise any queries you wish. In this way you will have the opportunity of discussing your local practices and problems with farmers from your district who are faced with similar problems. I feel that very valuable knowledge can be gained from such exchanges of experiences. A few typical problems which could be discussed are given below to start the ball rolling.

I shall look forward to meeting you and your friends and I am sure that you will find the discussion very instructive and well worth while.

Your sincerely,

F. A. E. SHARPE
District Advisory Officer

Points which could be discussed with advantage are given in the following examples:

Are the new strawberry varieties better than the old ones?
Is deep ploughing advisable?
Will potatoes keep this year?
Is Cappelle the best variety of wheat?
Can tulip eelworm be controlled?
Is it wise to plant once grown potato seed next year?

Conclusion

As I said earlier, it was the agricultural expansion programme that stimulated my interest in parish meetings. The C.A.O. for my county, Huntingdon, sent a personal letter to all farmers in one parish, inviting them to come and discuss ways and means of achieving the target. Some 30 turned up. The meeting was completely informal, and proved so successful in stimulating farmers' interest that a series of meetings continued in other parishes. Meanwhile, I moved to East Lancashire and adopted a similar formula for my meetings, bringing in the marginal production scheme as an important part of farm management.

After moving to Cornwall, I found that parish meetings again achieved a good response. Attendance ranged from 15 to over 100, with an average around 40. In Cornwall the scope was far greater due to the wider range of subjects: milk, beef, vegetables, grass, silage, hay, marginal and ploughing grants, cash crops, etc. There again, economics were introduced and target standards of production and costs for the different

types of farms were discussed. This created considerable interest, with subsequent developments at "farmhouse" meeting level, a subject discussed by Boyer in a previous number.[1]

The parish meeting has developed both as a routine means of getting over to the farmer the information he says he wants, and also as a useful "group approach" platform. Farmers invariably enjoy this type of meeting and I can recommend it to any D.A.O. (but only to D.A.O's). We cannot expect a lot of direct action from farmers, although on many specific technical points the parish meeting certainly saves individual visits. Mainly, however, it gets at another group of farmers who would not come to a formal lecture. It gives them a chance to air their problems, which will probably be similar problems to those of their neighbours. It enables the N.A.A.S. to show how it can help farmers and it also stimulates them into thinking about new ideas. The effects are cumulative and in my experience well worth while.

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The Written Word

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WHEN THE Small Farmer Scheme began, at least one District Advisory Officer was tempted to concentrate all his efforts on a small group of farmers. To counteract this tendency he realized he had to adopt more economical means of disseminating advice, and he discovered that the written word offered an excellent way to keep in touch with old friends and even make new ones.

A Look at the Editor's Desk

The obvious medium is the local press. This has a wide circulation and is read by people who might ignore a circular. If an editor has a good agricultural correspondent, the task is already being done. But usually the editor has not an agricultural specialist, and in these circumstances it is important to appreciate the editor's point of view.

Hand-outs

The editor already receives the Ministry's official hand-outs: he also gets many from other organizations. His neighbouring editors are likewise supplied. If a sudden fall of snow obliterates the sports page they may be very useful. But he runs the risk that his rival editor may

have selected the same hand-out. It may even have been used in an N.F.U. journal.

A local paper must be local, topical, and controversial. The local editor generally lacks the specialist knowledge necessary to add local colour to a hand-out and give it a topical twist. It is here that the advisory officer can help by giving local colour, and at the same time ensure that an important hand-out does not provoke controversy by being misinterpreted.

Feature Articles

Good agricultural articles are usually warmly welcomed because the editor needs the support of the rural as well as the urban reader. There is also a persistent urban interest in yeoman topics. Furthermore, good features can help to build an attractive "brand image" for the D.A.O.'s "goods"—his advice.

How we got Started

An invitation to the Ministry of Agriculture for a historical centenary article on farming gave an opening with the "Melton Mowbray Times". As a result, the editor's fear that officials wished to use him for propaganda was overcome, and a "Farming Commentary" series was arranged. The original aim was a thousand words a fortnight, soon to be changed to five hundred words a week, to help in planning the paper and catch the eye of the casual reader.

A local paper published weekly has staffing problems, so the articles had to be written six days ahead of publication. With leave and so on, occasional articles must be written even earlier. Irksome, but it is the editor who controls the paper and must be pleased. Here was a job to keep his compositor occupied when last week's edition had gone.

Enormous Scope

An opening like this offers enormous scope to put over advisory material. Given the right twist, routine technical education can slip in comfortably. Specific local warnings like wheat bulb fly constitute useful news as well as valuable advisory work. Once "in", a thing like a potato blight warning can be front page news if received in time.

The routine articles call for a special technique. A simple style, short sentences, and short paragraphs make for easy reading and an attractive layout. Many readers will look only at the first and last sentence in each paragraph, so don't leave too much in the middle.

The advisory material must have a leavening. Indeed, it must be skilfully camouflaged. An editor wants local names and genuinely local information. This presents obvious difficulties but there are many ways in which an article can get local colour. Use phrases such as "local farmers", "our own wet clays", "local tradition" and sympathize with "local

difficulties". If you have a Metereological Station, quote local rainfall. And it is worth remembering that it always encourages readers to highlight local reputation.

Reports of Advisory Meetings

Any evening meeting can always be written up or discussed. Even if the audience is small, here is one way of getting good value out of the speaker's effort. A tactful quote from a visiting speaker can bring in a bit of controversy. Controversy is one of the problems the District Advisory Officer himself dare not tackle. The only token can be odd research figures—perhaps a straw-burning trial!

The Fruits

Once established, the articles have a considerable effect. Farmers at market ask you for more information about something appearing in your articles. Others will want to disagree. Make sure that the editor gets to know of this interest. The articles are also read by people who don't know you. They are amongst the more important of your readers —the man who never seeks advice.

Another vitally important reader in the farming team is the worker. If he has a better idea of what lies behind his work he will make a better job—give him a word of encouragement as well. The last man who profits is the author. An ear is always open for information and an eye to news. There is much in the old saying that listening maketh a wise man, talking maketh a ready man, but writing maketh an exact man.

Regional Note

Development of Seed Potato Production in the Northern Region

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DEGENERATION of potatoes was mentioned by authors as long ago as the end of the eighteenth century. Tuke,[1] writing in 1800, says that in the North Riding dales, the farmers avoid "the curl" by planting on different soil: "but in the lower parts of the Riding the sets of the kinds for the table are procured either from the moorlands or from Scotland, and it is found necessary to renew them every year, or at least every other".

Soil factors were usually considered to be responsible for the improved vigour of this introduced seed, and it was not until 1916 that leaf-roll was recognized to be caused by a virus. In 1920, the mode of transmission of leaf-roll by aphids was established. Although more than twenty potato viruses have now been isolated only three are of direct economic importance, namely, leaf-roll virus and viruses X and Y. Of these three, virus Y and leaf-roll virus are chiefly responsible for degeneration of potato seed stocks, since virus X, although widespread, does not seriously affect the health of the plant.

Seed Growers' Associations

One of the results of the recognition of aphid-transmitted virus was the development of seed producing areas in the north of England. At a meeting held at Penrith in 1929, arranged by the Ministry of Agriculture, it was agreed to form a Cumberland Seed Potato Growers' Association. Later, similar associations were formed in Northumberland and Durham.

The advisory staff of King's College, Newcastle, in particular Dr. F. T. Bennett, were interested in the possibilities of producing good seed in the area, and for many years taught farmers how to recognize and rogue virus affected plants from their crops. Dr. Bennett also encouraged growers to form stock plots varying from a quarter to one acre, and to burn the haulm to limit virus spread.

In 1945–46 the seed potato growers' associations were amalgamated into one association known as the North of England Seed Growers' Association. The Association handled agricultural seeds as well as potatoes and through its purchase-sales-cum-advisory service did useful work in developing the seed potato growing industry. Unfortunately, the Association fell on unhappy times and was dissolved in 1953, its trading activities being taken over by the West Cumberland Farmers' Trading Society Limited.

The National Institute of Agricultural Botany has played no small part in the development and improvement of seed growing in the area. Before 1952 the Institute had sent occasional consignments of virus-tested stocks into the area. From 1952 onwards regular supplies were brought in and grown on contract for the first year on behalf of the Institute. In the second year these stocks were sold to selected growers in the best areas, leading to a steady distribution of high quality material over the seed growing districts.

Certification

The introduction of certification in 1918 and its subsequent development was described in the *N.A.A.S. Quarterly Review* No. 13, 1951. In 1945 the "Special Stock" scheme was introduced, and the certification scheme with its advisory bias contributed to rapid improvement in the health of stocks in the area.

The "S.S." scheme had a serious setback in 1946 when only one stock in Cumberland and Westmorland received an "S.S." certificate, owing to one of the worst epidemics of leaf-roll on record. Stocks passed "S.S." and "A" in 1945 showed up to 5 per cent and 15 per cent leaf-roll, respectively, in 1946.

However, the general health of stocks continued to improve steadily, and in 1947, 85 per cent of the acreage put forward for certification was passed. In 1953 the percentage passed was 99·7 and it has since remained within 2 to 3 per cent of this figure.

Area of Seed Production

The seed growing area in Cumberland is now more or less confined to a rectangular piece of country formed by Carlisle and Brampton in the north and Penrith and Appleby in the south, the area being roughly divided by the River Eden. A few crops are grown in north-east and west Cumberland, the latter being the residue of a once considerable interest.

The drop in the number of seed growers, with the resultant decline in acreage grown between 1948 and 1959 (Table 1) was due entirely to economic forces. The price of seed is tied to that of ware. Between these years, the margin gradually fell until those least interested in seed production found that there was more profit in growing ware potatoes.

In 1947, 16·5 per cent of the failed acreage was due to leaf-roll. In 1959 only 1·5 per cent was failed due to all causes. Timely removal of infection by roguing, the use of better stocks, and the effect of climatic conditions on the presence and movement of aphids may all have played their part.

Table 1

Acreage under Seed Potatoes in Cumberland in 1948 and 1959

Year	Total acreage	Growers	Lots	
			S.S.	Others
1948	641	111	127	104
1959	189	27	21	29

Recognition of Virus

In Cumberland and Westmorland the period for recognizing the virus is a very short one. Crops only grow slowly up to the end of June or the first week in July. After that they move very rapidly, and with the more generous use of fertilizers the tops soon meet across the rows, making it impossible to assess accurately the presence of such a small tolerance of virus as is demanded by the "S.S." scheme. Strictly speaking, there is only one inspection, and the time for that is when the tops are about to meet in the rows, a period of about ten days for any particular crop. Once this stage is past, inspection becomes very difficult and the final decision must be based on the inspector's knowledge of the crop and his experience.

Aphids and Virus Spread

The main spread of viruses is by winged spring migrant aphids (*Myzus persicae* Sulz.). Most infection occurs early in the season, soon after colonization; very little takes place after the beginning of August.

ROGUING

Roguing is carried out in all seed crops in the Region, but it does not take place early enough to defeat virus transmission. If it were carried out as soon as the early symptoms of virus infection appeared in the crop, i.e., not later than the end of July, roguing would be very effective. Ideally, the plants immediately adjacent to the infected plant would also have to be rogued, since it has been shown that they are most likely also to have been infected. It follows, therefore, that perfect roguing is impracticable.

In Cumberland and Westmorland, roguing was carried out extensively by the Seed Growers' Association and later by the Cumberland C.A.E.C.; at the present time it is done by the West Cumberland Farmers' Trading Society Ltd. Many growers now producing seed potatoes are experienced men who have been growing for a number of years and generally do their own roguing when necessary. It is now the practice with early varieties to burn off the haulm by the end of July or early August.

OTHER VIRUS CONTROL MEASURES

In the Northern Region, the maximum aphid population usually occurs by early or mid-August and the haulm of main crop varieties is not usually destroyed by burning off or blight infection before mid-August to early September. Growers could, with advantage, destroy the haulms earlier than usual, certainly before the development of winged migrant aphids. The common practice of allowing blight to destroy the tops is regrettable. For example, in 1956 at the Gt. Salkeld site (Table 3) 75 per cent blight occurred in early August but the tops were not burnt off until the end of the month. To be effective, burning off needs to be done before 50 per cent blight occurs.

Varieties

Redskin, a variety esteemed in Cumberland for its consistent cropping, good quality and keeping characteristics, has remained predominant over the years, with Majestic and Arran Pilot grown to a lesser degree. In 1947 and 1959, nineteen and eleven varieties, respectively, appeared on the certification list.

1947		1959
Redskin	Arran Peak	Redskin
Majestic	Stormont Dawn	Majestic
Arran Pilot	Dunbar Standard	Arran Pilot
Home Guard	Bintje	Dr. McIntosh
Ulster Chieftain	Epicure	Dunbar Standard
Ulster Ensign	Kerr's Pink	Craig's Royal
Ulster Earl	King Edward	Ulster Supreme
Vanguard	Eclipse	Arran Viking
Arran Banner	Arran Victory	Craig's Alliance
Great Scot		Arran Consul
		Home Guard

Virus Investigation

With increasing experience in certification and advisory work and the general improvement in the health of stocks, it became apparent that the seed growing area might usefully be extended. Additional information on the incidence of aphids and the consequent spread of virus was desirable before this extension could be achieved.

In 1950, Hollings[2] started a series of co-operative experiments in certain seed growing areas of England and Wales designed to establish criteria for assessing such areas. Four sites in Cumberland were included in the survey, two in areas disqualified for certification on grounds of insufficient altitude (Carlisle 100–200 ft and Dalston 250–300 ft), and two in the Eden Valley eligible for top grade ("S.S.") seed (Baronwood 450–550 ft and Kirkoswald 500–600 ft).

VIRUS SPREAD

The experiment was carried out at these sites for four successive years (1950–53) and counts of aphids on both plants and traps were made at regular intervals throughout the growing season. Special seed was used, free from leaf-roll and mosaic (virus Y). Sample tubers were taken at the end of each season and grown on in the following year. In this way a check was kept on the amount of virus spread in the crop.

Hollings found that an index of virus infection could be used to classify good and bad seed growing sites, and that 12 per cent of virus in the sample tubers represented the boundary between suitable and unsuitable sites.

Table 2

Experimental sites and Classification according to Virus Spread (after Hollings)

Site	Altitude ft	Spread of Virus Diseases							
		1950		1951		1952		1953	
		Leaf-roll	Mosaic	Leaf-roll	Mosaic	Leaf-roll	Mosaic	Leaf-roll	Mosaic
Carlisle	100–200	B	A	A	A	D	A	B	A
Dalston	250–300	C	A	A	A	A	A	A	A
Baron-wood	450–550	A	A	A	A	A	A	A	A
Kirkos-wald	500–600	A	A	A	A	B	A	A	A

A = very good, 0–5 per cent sample tubers infected
B = good, 6–12 per cent sample tubers infected
C = poor, 12–25 per cent sample tubers infected
D = very poor, over 25 per cent sample tubers infected

1950 and 1952 were years of very early aphid activity and a high level of virus spread: 1951 and 1953 had few aphids and little virus spread. It will be seen from Table 2 that the best seed sites, Baronwood and Kirkoswald, showed consistently low virus spread, even in bad years, whereas the other two sites had too great a virus spread in bad years to pass the highest seed standard. Dalston in 1950 and Carlisle in 1952,

had too high a leaf-roll index to reach "S.S." or "A" standard, although they were suitable for the "H" certificate. The mosaic figure was satisfactory at both centres in all four years. In the Northern Region the amount of leaf-roll can be used as an index of virus spread since mosaic (virus Y) is of much less importance.

Aphid Trap Data

An important result of this work was the establishment of a definite correlation between the spread of leaf-roll and the number and movement of *Myzus persicae*, as measured by aphid trap data.

By plotting aphid activity against time, an index, which Hollings termed the "angle of colonization", was obtained which could be used to indicate potential virus spread. A high angle of colonization (i.e., 55–60+) indicates a potentially high virus spread but, if there is little virus infection in the stock to begin with, then the actual virus spread may be small.

The second stage[3] of the potato virus investigation covered the years 1955, 1956, and 1957, and fourteen sites in the seed growing areas of the Northern Region were included in the national experiment. Seven of these fields were in Cumberland, one in Westmorland, from Longtown in the north to Appleby in the south: four fields were in north Northumberland and two in the North Riding. Except for the two North Riding fields and one in Northumberland, which were growing for "S.S." certificates, all the other fields were disqualified for high grade certificates on the score of altitude. Records of the colonization angles and leaf-roll percentages for these sites are given in Table 3.

The investigation showed that all the seed growing areas in the Northern Region produced excellent virus-free seed, even in "bad" virus seasons. Certain areas in Cumberland, notably around Dalston, Longtown and in the lower Eden Valley, produced eligible seed even though disqualified on the grounds of altitude. By contrast in other parts of the country, particularly the Cotswolds, seed production proved unsatisfactory because of the high virus incidence even in areas of eligible altitude.

In Northumberland, Durham and the North Riding, severe mosaic is more prevalent than in Cumberland and Westmorland, and except in a few cases anything less than 400 ft should probably not be regarded as a safe altitude. Excellent seed growing areas do exist in the eastern half of the Region and are probably little, if at all, inferior to the best Cumberland sites.

Reconsideration of Altitude Limitation

There is clear evidence that there is a case for reconsidering the altitude limitation in certain areas in Cumberland abutting the main seed growing parts. Several of the fields in the Eden Valley visited during the

course of the above investigation were on farms where land was divided by the 400 ft contour. Owing to the exigencies of rotation such farms would be eligible for certification one season and not the next. It would never be worth while to attempt to grow top grade seed potatoes in the vicinity of urban areas, with their potential of Brassica hosts for over-wintering aphids, but areas a few miles away from Carlisle and Penrith, even at quite low altitudes, proved remarkably virus-free. Probably only in exceptional "aphid years" would there be difficulty in keeping the desired standard.

Table 3

Assessment of Potato Seed Growing Sites as Shown by Colonization Angle and Leaf-roll percentage, 1955–57 (after Hollings)

Site	Altitude ft	Variety	Colonization angle			Percentage leaf-roll		
			1955	1956	1957	1955	1956	1957
Appleby (Westmorland)	350	Redskin	54	57	64	0	0	0
Brampton (Cumberland)	200	Redskin	47	37	66	0·1	0·05	0
Cumwhitton (Cumberland)	400	Redskin	48	54	Not surveyed	0·25	0	Not surveyed
Dalston (Cumberland)	250	Redskin	32	60	54	0·5	0·15	0
Edenhall (Cumberland	400	Redskin	33	55	55	0·5	0·45	0
Longtown (Cumberland)	50	Redskin	27	51	34	0·05	0·05	0·05
Longtown Woods (Cumberland)	50	Redskin	Not surveyed	25	Not surveyed	Not surveyed	0	Not surveyed
Gt. Salkeld (Cumberland)	300	Redskin	25	59	58	0·25	0·1	0·1
Scaleby (Cumberland)	100	Redskin	41	47	57	0·1	0·05	0·1
Camphill (Northumberland)	450	Majestic	44	56	52	0	0·05	0
Hetton Steads (Northumberland)	350	Majestic	45	38	34	0	0·25	0·05
Mardon (Northumberland)	175	Majestic	Not surveyed	60	54	Not surveyed	0·1	0
W. Learmouth (Northumberland)	100	Great Scot	Not surveyed	58	61	Not surveyed	0·05	0
Thirsk (N. Riding)	900	Majestic 1955 Bintje 1956 & 1957	24	9	52	0	0	0·01
Leyburn (N. Riding)	550	Majestic	26	34	Not surveyed	0	0	Not surveyed

A direct result of the long term efforts to improve the health of seed potato stocks in the Northern Region has been the decision to de-restrict the altitude limits in part of the Eden Valley in Cumberland. In 1961 there will be no altitude restriction on growing seed potatoes for "A" certificate in an area bounded by Gilsland in the north, the Carlisle-Penrith road in the west, the county boundaries of Cumberland, Westmorland, and Yorkshire in the south and the Pennines in the east. In 1960, a new seed growers' association was formed in Co. Durham, with the aim of resuscitating interest in seed production in that county.

The evolution of an area, once virus ridden, to one relatively free

from potato virus diseases affords considerable satisfaction to all who have been concerned with these developments from their commencement. The Region is indeed favoured by nature for the production of good seed, in that isolation is excellent and the normal farm rotation long, both important factors in seed potato production.

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